



# ATD-1: Avionics and Ground Automation Prototyping Progress

Presentation to CNS Task Force

William C. Johnson

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# Outline



- **Overview of ATD-1**
- Simulations
- Prototyping
- Technology Transfer
- Next Steps



# ATD-1 Formulation



- In 2010
  - Elements of NASA terminal ATM research progressed to high-fidelity human-in-the-loop (HITL) simulations. Stakeholder input and feedback was positive; the research aligned with FAA priorities
- In 2011
  - Office of Management and Budget and Congress requested NASA to:
    - Accelerate ATM technology transition, including ADS-B In
    - Conduct more relevant flight research emphasizing enhancing aviation safety and airspace efficiency
    - ATD-1 initiated as part of the Systems Analysis, Integration, and Evaluation Project within NASA's Airspace Systems Program
- In 2012
  - The ADS-B In Aviation Rulemaking Committee and FAA Reauthorization identified the need to test the use of ADS-B technologies in the most congested airspace



# ATD-1 Objectives



- Demonstrate increased, more consistent use of Performance-Based Navigation (PBN)
  - RNAV/RNP arrival procedures from cruise to touchdown
  - Optimized Profile Descents (OPD) using speed control
  - Simultaneous high throughput and fuel-efficient terminal ops
- Demonstrate ADS-B In Spacing Application
  - NASA ADS-B In merging and spacing algorithm (ASTAR)
- Accelerate transfer of NASA scheduling and spacing technologies for inclusion in late mid-term NAS
  - Terminal metering based upon Traffic Management Advisor research
  - Airborne spacing application based upon Interval Management research
  - Controller spacing tools based upon Controller Managed Spacing research



# Integrated Arrival Solution



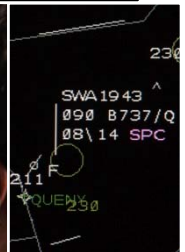
**FIM**

Flight Deck Interval Management  
for Arrival Operations



**CMS**

Controller-Managed Spacing  
in Terminal Airspace



**TMA-TM**

Traffic Management Advisor  
with Terminal Metering



NASA Technologies  
plus

ADS-B Infrastructure

Area Navigation (RNAV) Arrivals

Required Navigation Performance (RNP)

Optimized Profile Descents (OPD)



# ATD-1 Movie





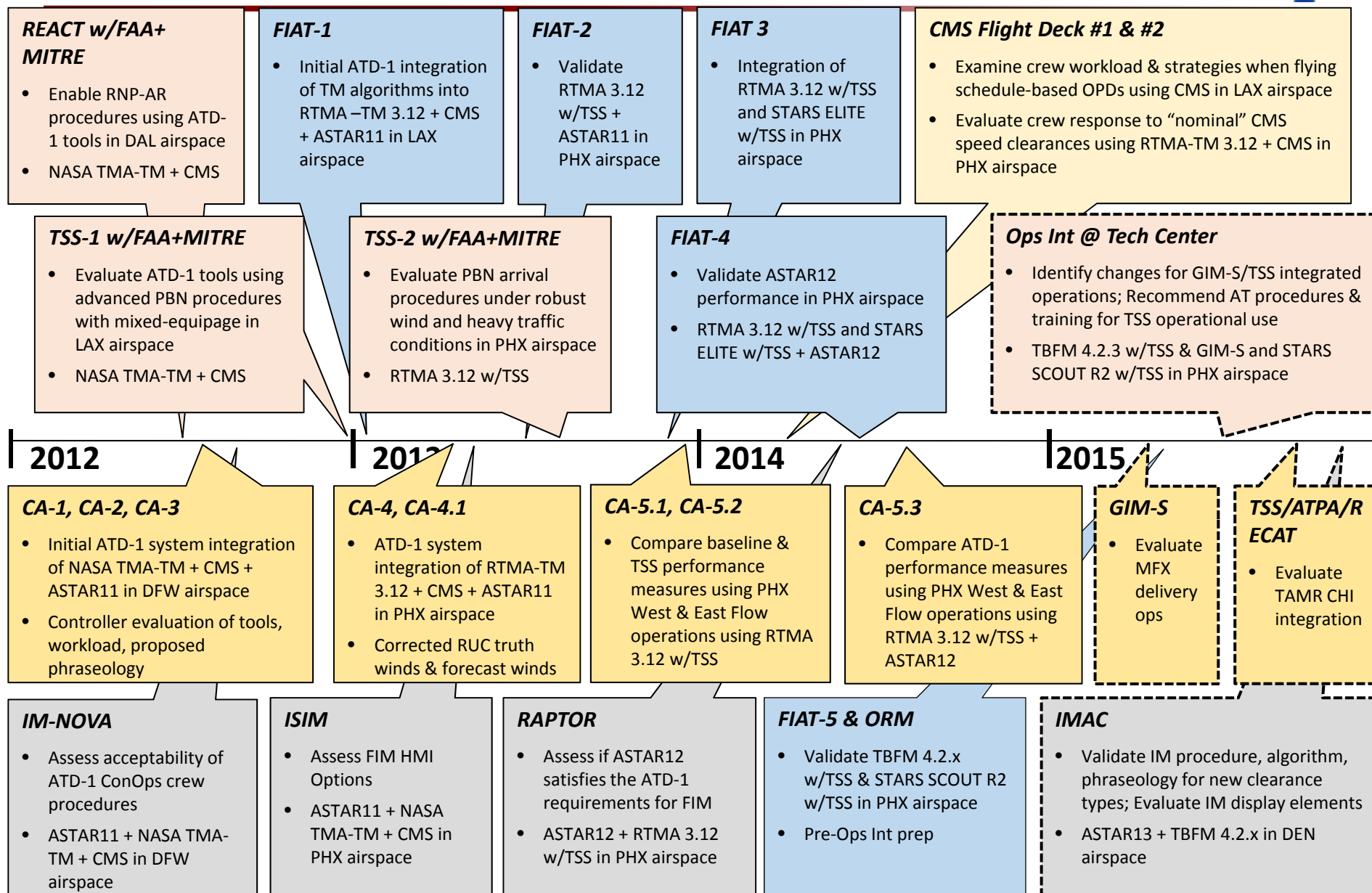
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# ATD-1 HITL Simulations (FY)







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# Prototyping



- Ground Automation
  - Traffic Management Advisor (TMA)
    - FAA Trajectory Based Flow Management (TBFM) Program
  - Standard Terminal Automation Replacement System (STARS)
    - FAA Terminal Automation Modernization and Replacement (TAMR)
- Airborne Automation
  - Flight deck Based Interval Management (FIM) System
    - FAA Surveillance and Broadcast Services (SBS) Interval Management (IM) Project
    - RTCA Special Committee 186 (SC-186) Working Group-4 (WG-4)/EUROCAE Working 51 (WG51)



# STARS Prototyping



- Prototyping initiated in 2011 with Raytheon
- Phase 1:
  - Feasibility and trade studies for incorporating TSS and IM functionality in STARS ELITE
    - IM functionality scoped for demonstration purposes
- Phase 2:
  - Prototyping TSS and IM functionality into STARS Elite
  - Installation and support of STARS at NASA Ames
  - Software delivery, installation and support for STARS at the FAA Technical Center for the NASA/FAA TSS Operational Integration Assessment (OIA)



# NASA at the STARS Test Facility





# TBFM Prototyping



- TMA Prototyping initiated by NASA Engineers
- TSS and IM functionality was integrated into testing version of TBFM 3.12 and later TBFM 4.2 and finally TBFM 4.2.3
  - IM functionality scoped for demonstration purposes
- A number of TBFM improvements were required to enable TSS functionality (Trajectory modeling, Flex scheduling, and more)
- Inputs fed into TBFM Investment Decisions
- Developed and delivered a small portable TBFM test platform to the FAA Technical Center



# FIM Avionics Prototyping



- Prototyping Initiated in 2012
- Phase 1:
  - Feasibility and trade studies performed by the Boeing Company
  - NASA Airborne Spacing Terminal Arrival Route (ASTAR) FIM algorithm was demonstrated in flight test cabs at Boeing facilities using ACSS system
- Phase 2:
  - Build and flight test FIM system based on ASTAR using integrated avionics
  - More on this later in this presentation...



# ASTAR Flight Test



- Proof-of-concept ADS-B In application flight test in December 2014
- Purpose:
  - Assess risks associated with ADS-B In application flight trials
  - Get an initial look at NASA FIM application performance
- FIM application on board Boeing EcoDemonstrator 787
- Limited runs into Moses Lake, WA and SEATAC
- Boeing also provided second aircraft as ADS-B Out source
- NASA and Boeing staff monitored operations from ZSE and MWH
- Conducted successfully and results were positive
- Media
  - <http://www.nasa.gov/press/2014/december/nasa-tests-software-that-may-help-increase-flight-efficiency-decrease-aircraft/>
  - <http://www.ainonline.com/aviation-news/air-transport/2014-12-18/boeing-concludes-latest-round-ecodemonstrator-trials>





# NASA Testing on the Boeing EcoDemonstrator 787







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# Tech Transfer



- ConOps
- Simulation Results
  - TSS, FIM and Integrated
- STARS Development
  - Systems Engineering
  - Software
  - Documentation
- Avionics Development
  - Systems Engineering
  - Software
  - Hardware
  - Documentation
- FAA Investment Decision Support



# TSS Technology Transfer to FAA





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# NASA/FAA

## Operational Integration Assessment



- Objective:
  - **Demonstrate TSS at the FAA Technical Center with NATCA controller participants in order to identify TSS operational integration risks**
- Implement TSS capabilities in prototypes of FAA operational systems
  - TBFM 4.2.3 NASA Prototype with TSS capabilities
  - STARS ELITE R2 NASA Prototype with TSS advisory tools
  - ERAM 15200 with GIM-S capabilities
- Scenarios
  - Phoenix Sky Harbor International Airport (PHX), Phoenix TRACON (P50), Albuquerque and Denver ARTCC
  - GIM-S configured with extended metering
  - Off-nominal events
- NATCA Controller Participants and Traffic Managers
- Final testing will be completed in May



# FIM Flight Test Plans



- Objective:
  - Demonstrate ADS-B In Application
  - Accelerate transfer of NASA scheduling and spacing technologies
- Working with industry to conduct a flight test in early 2017 to test a FIM avionics system installed in the cockpits of two air transport class aircraft
- FIM system will be based on ASPA-FIM MOPS currently under review in RTCA
- Range of FIM clearances as defined by the RTCA will be tested in both center and terminal airspace
- Results, hardware, software, documentation will be delivered to the FAA for further development



# Concluding Remarks



- NASA is working with NAS stakeholders to improve high density terminal arrival operations by developing the concepts and prototypes, and providing expertise to accelerate a key ADS-B In Application and merging and sequencing tools for NextGen
- TMA-TM and CMS technologies have been transferred to the FAA where they became TSS
- FIM concepts and technologies are being developed for a flight test and subsequent transfer to the FAA for further development and testing